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AEROSPACE INFORMATION REPORT

SAE AIR4012 REV. A

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Superseding AIR4012

Military Service Experience - Aircraft Wheels

1. SCOPE:

This SAE Aerospace Information Report (AIR) is intended to provide general background on aircraft wheel service lives on military aircraft and wheel laboratory test requirements as specified by military procurement agencies or aircraft manufacturers. Wheel service life in this document refers to the lowest life wheel half or flange in a wheel assembly measured in years (excluding bearing, bolt, and other removals). This information is intended as a reference guide for those responsible for specifying original equipment (OE) wheel laboratory test requirements.

1.1 Background:

This study was precipitated by complaints from the military services (Air Force, Navy) of low wheel life on certain OE wheels on new aircraft. Low wheel life was cited as a chief concern by the former Air Force Logistics Command (AFLC), now Air Force Materiel Command (AFMC) with respect to supportability, and hence combat readiness of new aircraft. It should be noted, however, that low wheel life is not a problem on all new aircraft programs.

Helicopter wheel service life histories are not included in this document, however, one manufacturer reported that the 250 roll mile requirement specified in MIL-W-5013 is inadequate for present-day helicopter operations. This manufacturer has increased roll requirements to 2000 miles or more to address continuing problems with wheel failures.

From an overall perspective, low OE wheel life can in part be attributed to conflicting requirements and/or perceptions on “acceptable” wheel lives within military and industry communities.

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1.1.1 What is Acceptable OE Wheel Life?: One survey response, indicated in Figure 1, suggested a spread of approximately 4 years between wheel life goals of performance and logistics oriented communities. The result is best summarized by the following example:

In the past, logistic procurement cycles within the former AFLC were based upon a 10 year minimum wheel life assumption. At the same time, wheels were being designed to specifications which were, in general, more compatible with performance (weight and roll mile) objectives. Subsequently, wheel life was considered to be low by the logistics community when wheel service lives did not meet the 10 year minimum life assumption. Passive procurement practices, coupled with long manufacturing lead times led to wheel shortages, hence supportability difficulties.

Examples of conflicting specification requirements and logistics expectations are noted in 3.1.

The foregoing highlights consensus and document issues to be resolved within the procuring agencies.

1.1.2 What are the Time Based Means for Assessing Wheel Service Life?: The USAF defines “time/ inspection counter intervals (months) and special field level inspections” for all type aircraft wheels in maintenance and overhaul instructions. By tracking the number of inspections and overhauls it is possible to arrive at minimum wheel life assessments on most wheel models. On some wheel models, inspection is only specified at each tire change. The US Navy inspects wheels at tire change intervals based upon aircraft model. Wheels are retired from service based on condition and wheel lives are not recorded. As with some USAF wheels, wheel half tracking by serial number is one method available to the US Navy to determine years in service.

One commentator suggested that roll mileage should be tracked to assess service life which cannot be done with present tracking practices.

From the wheel vendor’s point of view, wheel service life is dependent upon a large number of variables such as tire characteristics, wheel static load requirements, roll spectrums, vendor design and test procedures, actual airplane operational loads and environments, wheel corrosion protection and handling practices. There is evidence on some models that aircraft manufacturer wheel laboratory test procedures and vendor design practices have combined to yield acceptable OE service lives.

2. APPLICABLE DOCUMENTS:

The following publications form a part of this specification to the extent specified herein. The latest issue of SAE publications shall apply. The applicable issue of other publications shall be the issue in effect on the date of the purchase order. In the event of conflict between the text of this specification and references cited herein, the text of this specification takes precedence. Nothing in this specification, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

QUESTION

IN YOUR JUDGMENT WHAT FIELD SERVICE MAIN WHEEL LIFE DO YOU CONSIDER TO BE A DESIRABLE BALANCE BETWEEN WEIGHT SAVINGS (PERFORMANCE) AND MAINTENANCE/LOGISTICS?

A) FIGHTER/BOMBER AIRCRAFT

SERVICE LIFE (YRS.) _____

LANDING CYCLES _____

ROLL MILES _____

B) CARGO/TANKER AIRCRAFT

SERVICE LIFE (YRS.) _____

LANDING CYCLES _____

ROLL MILES _____

RESPONSE

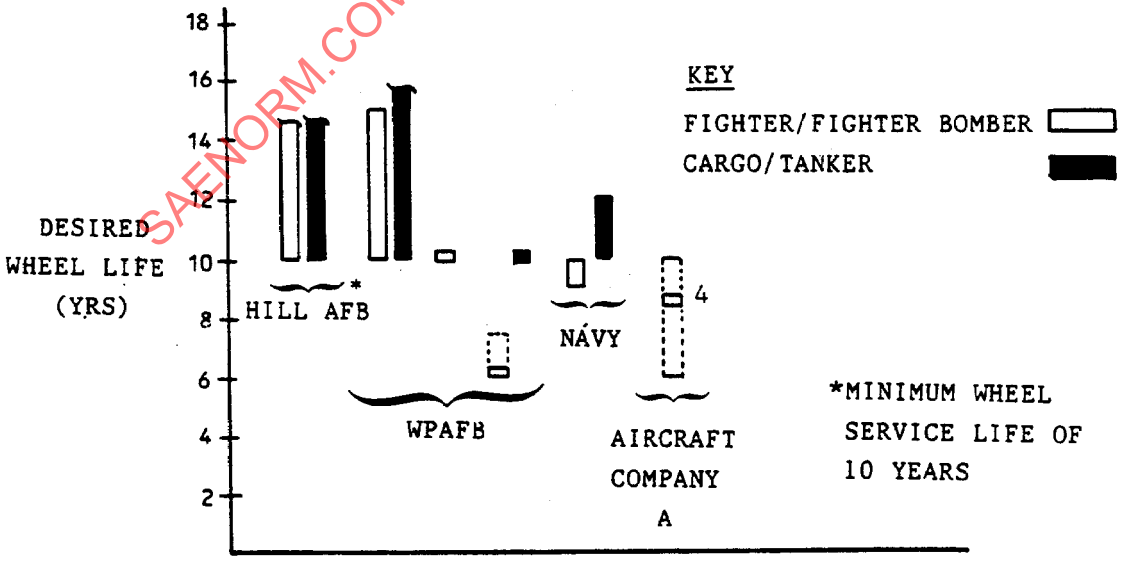

FIGURE 1 - Perceptions on Desirable Wheel Service Lives (1983 Survey)

2.1 SAE Publications:

Available from SAE, 400 Commonwealth Drive, Warrendale, PA 15096-0001.

AIR811 Disposition of Overheated Wheels
ARP1493 Wheel and Brake Design and Test Requirements for Military Aircraft

2.2 U.S. Government Publications:

Available from DODSSP, Subscription Services Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-L-87139 (USAF)

MIL-W-5013

AFGS-87249 Mechanical Equipment and Subsystem, Requirements for the Integrity of

MIL-STD-1798 Mechanical Equipment and Subsystem Integrity Program

2.3 Other Publications:

Aircraft Manufacturer Wheel/Brake Procurement Specification

3. WHEEL LABORATORY TEST REQUIREMENTS:

3.1 Procurement Documents:

3.1.1 US Air Force:

a. MIL-L-87139 (USAF)
b. AFGS-87249, Mechanical Equipment and Subsystem, Requirements for the Integrity of
c. MIL-STD-1798, Mechanical Equipment and Subsystem Integrity Program

3.1.2 Aircraft Manufacturer Wheel/Brake Procurement Specification: The current Air Force approach of addressing wheel service life is outlined in MIL-L-87139 (USAF). Overall responsibility on the definition of wheel laboratory test requirements is relegated to the aircraft manufacturer. Based upon analyses and/or prior experiences, the aircraft manufacturer estimates wheel laboratory test requirements to yield the desired service life objective. The following excerpt from MIL-L-87139 (USAF) is provided for reference:

"The conditions must account for maximum gross weight usage (taxi and takeoff), design mission takeoff, landing, and taxi. A spectrum should be generated to simulate the anticipated load distribution to give the required life. The environment developed by the wheel-brake-tire combination must be accounted for in the design conditions of the wheels."

3.1.2 (Continued):

In comparison to earlier procurement specifications (MIL-W-5013) this approach offers flexibility in specifying wheel design criteria which focuses on intended missions and life cycle cost objectives. Variability in aircraft manufacturer wheel laboratory test requirements and philosophies may contribute to continued variability in OE wheel service lives. Since this approach is relatively new, experience on newer and future aircraft must be accrued to determine if specific instances of low OE wheel life have been substantially reduced or eliminated.

Examples of incompatibilities between procurement documents and wheel life expectations are noted below to highlight typical changes needed in the procurement area.

a. MIL-L-87139 (USAF), paragraph 3.2.3.2-b requires that "average" field service life should be specified. Former AFLC life expectations were expressed in terms of minimum wheel life. Given the statistical distribution of failures, the average requirement of MIL-L-87139 (USAF) was recommended in the prior issue of this document.

b. MIL-L-87139 (USAF) intent is that average wheel service life be determined by the "function of the type of air vehicle on which it will be installed and the overall logistic plan." Regarding wheel life typical goals, it is stated: "10,000 service miles for cargo air vehicle is consistent with airline criteria. Two thousand service miles for high performance air vehicle wheels seems to reflect the primary concept of design."

   It is recommended that these sentences be modified or deleted since the goals can be incompatible with life objectives in Figure 1 of this document:

   Examples:

   (1) Fighter Aircraft Scenario:

      (a) Peacetime
      (b) 100% spares
      (c) 200 to 250 missions/year
      (d) 4 to 5 roll miles/mission

      At 2000 service miles, average life = 3.2 to 5 years

   (2) Airline Service Miles: Typical service mile requirements range from 25 000 to 50 000 miles for more recent commercial aircraft.

c. Currently, two events are expected to alter items (a) and/or (b). The first is incorporation of MESCIP (Mechanical Equipment System Component Integrity Program) according to AFGS-97249 and MIL-STD-1798. The second is the merging of the former AFLC (Air Force Logistics Command) and AFSC (Air Force Systems Command) into AFMC (Air Force Materiel Command).

3.1.3 U.S. Navy:

a. MIL-W-5013L: The Navy approach to improving wheel service life has been to accept or modify earlier versions of MIL-W-5013. Table 1 summarizes the increased intensity of wheel laboratory test requirements from MIL-W-5013G to MIL-W-5013L versions. Service experience shows significant life improvement for wheels qualified under later versions of MIL-W-5013 and used on two carrier aircraft. MIL-W-5013L is the latest version (released 31 October 1991).

4. FIELD SERVICE EXPERIENCE:

Figures 2 and 3 illustrate responses to two survey questions regarding field service experience on wheels with bias ply tires. Figure 2 response indicates that wheel corrosion was ranked as the number one cause for retirement of wheels from service. The former AFLC and Navy report that the wheel condemnation rate for “general corrosion” increases as the average wheel life on a given model increases. In these cases, diligent attention to wheel corrosion protection practices (anodic treatment, paint systems, etc.) and more generous corrosion cleanup allowances are more important than increasing wheel structural design criteria (roll spectrums, etc.). The importance of maintaining wheels in accordance with wheel vendor recommendations is clear if maximum service life is to be attained. Corrosion protection of wheels in storage must also be practiced.

Wheel softness condemnation rates are also relatively independent of wheel structural design criteria. Wheel softness may result from initial design temperature control provisions and/or field service conditions in excess of specifications thermal design requirements.

Condemnation of wheel due to fatigue (emanating from corrosion pits, stress risers, etc.) in general increases percentage wise as the average wheel service life of a particular model decreases. In this regard, improvements in wheel laboratory test requirements of Section 3 can be effective in avoiding low OE wheel service lives.

Figure 3 illustrates approximate current wheel service life ranges on eight military aircraft. Hill AFB reported OE wheel service life to be inadequate on seven models which included trainer, fighter, and cargo aircraft. Current wheel service life on three of the seven models is included in Figure 3.

The bar charts suggest that most wheels are now achieving adequate service lives. In some cases, wheel design iterations were necessary to accommodate low OE service life, increases in aircraft gross weights, and/or changes in field service operations.

5. DOCUMENT REVIEW:

This document will be reviewed and updated every 5 years to provide information on wheel experience on newer aircraft, wheel material technological advances, wheel life experiences with radial tires, procurement document changes, and other relevant areas.

PREPARED BY SAE SUBCOMMITTEE A-5A, WHEELS, BRAKES, AND SKID CONTROLS
OF COMMITTEE A-5, AEROSPACE LANDING GEAR SYSTEMS

TABLE 1 - Comparison of Wheel Static and Roll Test Requirements

TABLE1A - Static Tests

	MIL-W-5013 Version G	MIL-W-5013 Version H	MIL-W-5013 Version J	MIL-W-5013 Version K	MIL-W-5013 Version L
YIELD RADIAL LOAD TEST (Ground Based and Carrier Based Aircraft)					
Apply 1.15 times maximum limit load at 0°, 90°, 180°, 270°, 0°, 0° with rated tire pressure	X	X	X	X	X
ULTIMATE RADIAL LOAD TEST (Ground Based and Carrier Based Aircraft)					
Apply 1.50 times maximum limit load at 0° with rated tire pressure and hold at least 10 s	X	X	X	X	X
Reapply radial load until wheel fails			X	X	X
DESIGN LANDING RADIAL LOAD TEST					
(A) Ground Based Aircraft					
Apply maximum design landing load with maximum design operating tire pressure and hold for not less than 10 s	X	X	X	X	X
(B) Carrier Based Aircraft					
Apply maximum design landing load, with maximum operating tire pressure, through a 1-3/8 in cable and hold for not less than 10 s	X	X			
Apply maximum design landing load, with maximum operating tire pressure, through a 1-1/2 in cable and hold for not less than 10 s. Same wheel and brake assembly rolled 5000 ft at rated static load.			X	X	X
YIELD COMBINED LOAD TEST (Ground Based and Carrier Based Aircraft)					
Apply 1.15 times the maximum limit combined load components to the wheel supported at 0°, 90°, 180°, 270°, 0°, 0° with rated tire pressure or carrier design pressure and hold for minimum of 10 s. Test must be performed on inboard and outboard of same wheel.	X	X	X	X	X
ULTIMATE COMBINED LOAD TEST					
Apply 1.50 times the maximum limit combined load components to the wheel supported at 0° with rated tire pressure or carrier design pressure. Hold for minimum of 10 s and no cracks. (J through L versions provide load block or inflation pressure alternatives.)	X	X	X	X	X
Holding side load constant or allowed to proportionally increase with vertical load the vertical load should be increased to wheel failure.			X	X	X

TABLE1A - Static Tests (Continued)

	MIL-W-5013 Version G	MIL-W-5013 Version H	MIL-W-5013 Version J	MIL-W-5013 Version K	MIL-W-5013 Version L
BURST TEST					
(A) Noncarrier Aircraft					
Using hydrostatic pressure in the tire, test the wheel to a burst pressure of 3.5 times the rated tire pressure, at the rated static load of the wheel or to the burst strength of the tire, whichever is least	X	X	X	X	X
(B) Carrier Aircraft					
Using hydrostatic pressure in the tire, test the wheel to a burst pressure of 4.5 times the rated tire pressure, at the rated static load of the wheel or to the burst strength of the tire, whichever is least	X	X	X	X	X

TABLE 1B - Roll Tests

	MIL-W-5013 Version G	MIL-W-5013 Version H	MIL-W-5013 Version J	MIL-W-5013 Version K	MIL-W-5013 Version L
THERMAL CONDITIONING (Ground Based and Carrier Based Aircraft)					
Prior to roll testing, wheels shall have been subjected to thermal conditioning equivalent to the cumulative temperature-time history resulting from brake heat dissipation experienced during dynamic torque tests except for the rejected takeoff condition.		X	X	X	X
STRAIGHT ROLL					
(A) Ground Based Aircraft					
1500 miles with an applied load equivalent to maximum taxi gross weight and rated tire inflation pressure[1]	X	X			
2670 miles with the rated static load applied and rated tire inflation pressure[2]			X	X	X
(B) Carrier Based Aircraft					
1770 miles with the rated static load applied and rated tire pressure inflation			X	X	X
900 miles with the rated static load applied and high pressure tire inflation			X	X	X
YAW ROLL (Ground Based and Carrier Based Aircraft)					
75 miles each inboard and outboard yaw with combined radial and side loads corresponding to a 0.25 g turn at maximum design gross weight using rated tire pressure		X			
150 miles each inboard and outboard yaw with combined radial and side loads corresponding to a 0.25 g turn at maximum design gross weight using rated tire pressure			X	X	X